What is claimed is:

1. A speech communication apparatus comprising:

a signal output transducer for receiving a distant signal from a far-end talker and producing acoustic energy of the distant signal;

a signal input transducer for producing a near-end signal which may contain a component representing a speech activity of a near-end talker or an acoustic echo component, or both, wherein said acoustic echo component occurs as a result of the distant signal being transmitted through an acoustic echo path from the signal output transducer to the signal input transducer;

an echo canceller for producing an echo replica from said distant signal and a residual echo;

a residual echo detector for detecting a difference between said near-end signal and said echo replica and supplying the difference as said residual echo to said echo canceller; and

a spectral shaper for receiving one of said near-end signal and said residual echo as a first input signal, receiving said echo replica as a second input signal, estimating from the first and second input signals said acoustic echo component when said speech activity is low or zero, and shaping spectrum of said first input signal with the estimated acoustic echo component.

2. The speech communication apparatus of claim 1, wherein said spectral shaper estimates said acoustic echo component for each of a plurality of subband frequencies of audio spectrum.

3. The speech communication apparatus of claim 1, wherein said spectral shaper estimates said acoustic echo component from a ratio of said first input signal to said second input signal.

4. The speech communication apparatus of claim 1, wherein said spectral shaper estimates said acoustic echo component from a ratio of said first input signal to said second input signal for each of a plurality of subband frequencies of audio spectrum.

5. The speech communication apparatus of claim 1, wherein said spectral shaper comprises:

means for dividing said first input signal into a first set of subband frequency component signals;

means for dividing said second input signal into a second set of subband frequency component signals;

a plurality of subband spectral shaping means, each of the subband spectral shaping means receiving a corresponding one of the first set of subband frequency component signals as a first subband signal, receiving a corresponding one of the second set of subband frequency component signals as a second subband signal, producing an estimate of a subband acoustic echo component from the first and second subband signals, and shaping the first subband signal with the estimate of the subband acoustic echo component; and

means for combining output signals of said plurality of subband spectral shaping means.

6. The speech communication apparatus of claim 5, wherein each of said subband spectral shaping means comprises:

a division circuit for producing a ratio of said first subband signal to said second subband signal;

a smoother for smoothing said ratio when said speech activity is low or zero;

a multiplier for multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo

component; and

a subtractor for producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

7. The speech communication apparatus of claim 6, wherein said smoother includes means for causing said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

8. The speech communication apparatus of claim 6, wherein said division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said ratio is produced.

9. The speech communication apparatus of claim 8, wherein said first smoother includes means for causing said first subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition, and wherein said second smoother includes means for causing said second subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

10. The speech communication apparatus of claim 5, wherein each of said subband spectral shaping means comprises:

a first division circuit for producing a first ratio of said first subband signal to said second subband signal;

a second division circuit for producing a second ratio of said second subband signal to said first subband signal;

a first smoother for smoothing said first ratio when said speech activity is low or zero;

a first multiplier for multiplying the smoothed first ratio by said second ratio;

a second smoother for smoothing the output of said first multiplier;

a subtractor for subtracting integer 1 from the output of the second smoother; and

a second multiplier for multiplying said first subband signal by the output of the subtractor.

11. The speech communication apparatus of claim 10, wherein said first smoother includes means for causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

12. The speech communication apparatus of claim 10, wherein said first division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said first ratio is produced.

13. The speech communication apparatus of claim 1, further comprising a harmonics generator for emphasizing harmonics components of said distant signal contained in said echo replica from said echo canceller.

14. The speech communication apparatus of claim 1, wherein said echo canceller comprises:

means for dividing said residual echo into a first set of subband frequency component signals;

means for dividing said distant signal into a second set of subband frequency component signals;

an adaptive filter bank for adaptively filtering said second set of subband frequency component signals according to said first set of subband frequency component signals;

means for combining output signals of said adaptive filter bank to produce said echo replica; and

means for nullifying the first set of subband frequency component signals when said speech activity is high,

wherein said spectral shaper comprises:

a plurality of subband spectral shaping means, each of the subband spectral shaping means receiving a corresponding one of the first set of subband frequency component signals as a first subband signal, receiving a corresponding one of the output signals of said adaptive filter bank as a second subband signal, producing an estimate of a subband acoustic echo component from the first and second subband signals, and shaping the first subband signal with the estimate of the subband acoustic echo component; and

means for combining output signals of said plurality of subband spectral shaping means.

15. The speech communication apparatus of claim 14, wherein each of said subband spectral shaping means comprises:

a division circuit for producing a ratio of said first subband signal to said second subband signal;

a smoother for smoothing said ratio when said speech activity is low or zero;

a multiplier for multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo component; and

a subtractor for producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

16. The speech communication apparatus of claim 15, wherein said smoother includes means for causing said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

17. The speech communication apparatus of claim 15, wherein said division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said ratio is produced.

18. The speech communication apparatus of claim 17, wherein said first smoother includes means for causing said first subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition, and wherein said second smoother includes means for causing said second subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

19. The speech communication apparatus of claim 14, wherein each of said subband spectral shaping means comprises:

a first division circuit for producing a first ratio of said first subband signal to said second subband signal;

a second division circuit for producing a second ratio of said second subband signal to said first subband signal;

a first smoother for smoothing said first ratio when said speech activity is low or zero;

a first multiplier for multiplying the smoothed first ratio by said second ratio;

a second smoother for smoothing the output of said first multiplier;

a subtractor for subtracting integer 1 from the output of the second smoother; and

a second multiplier for multiplying said first subband signal by the output of the subtractor.

20. The speech communication apparatus of claim 19, wherein said first smoother includes means for causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

21. The speech communication apparatus of claim 19, wherein said first division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said first ratio is produced.

22. A speech communication apparatus comprising:

a signal output transducer for receiving a distant signal from a far-end talker and producing acoustic energy of the distant signal;

means for dividing said distant signal into a first set of subband frequency component signals;

a signal input transducer for producing a near-end signal which may contain a component representing a speech activity of a near-end talker or an acoustic echo component, or both, wherein said acoustic echo component occurs as a result of the distant signal being transmitted through an acoustic echo path from the signal output transducer to the signal input transducer;

means for dividing said near-end signal into a second set of subband frequency component signals;

a plurality of subband echo suppressors, each of the subband echo suppressors comprising:

an echo canceller for producing an echo replica from a corresponding one of said first set of subband frequency component signals and a subband residual echo;

a residual echo detector for detecting a difference between a corresponding one of said second set of subband frequency component signals and said echo replica and supplying the difference as said residual echo to said echo canceller; and

subband spectral shaping means for receiving said residual echo as a first subband input signal, receiving said echo replica as a second subband input signal, estimating from the first and second input signals said acoustic echo component when said speech activity is low or zero, and

shaping said first subband input signal with the estimated acoustic echo component to produce an output signal of the subband echo suppressor, and

means for combining the output signals of said plurality of subband echo suppressors.

23. The speech communication apparatus of claim 22, wherein said subband spectral shaping means comprises:

a division circuit for producing a ratio of said first subband signal to said second subband signal;

a smoother for smoothing said ratio when said speech activity is low or zero;

a multiplier for multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo component; and

a subtractor for producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

24. The speech communication apparatus of claim 23, wherein said smoother includes means for causing said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

25. The speech communication apparatus of claim 23, wherein said division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said ratio is produced.

26. The speech communication apparatus of claim 25, wherein said first smoother includes means for causing said first subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition, and wherein said second smoother includes means for causing

said second subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

27. The speech communication apparatus of claim 22, wherein each of said subband spectral shaping means comprises:

a first division circuit for producing a first ratio of said first subband signal to said second subband signal;

a second division circuit for producing a second ratio of said second subband signal to said first subband signal;

a first smoother for smoothing said first ratio when said speech activity is low or zero;

a first multiplier for multiplying the smoothed first ratio by said second ratio;

a second smoother for smoothing the output of said first multiplier;

a subtractor for subtracting integer 1 from the output of the second smoother; and

a second multiplier for multiplying said first subband signal by the output of the subtractor.

28. The speech communication apparatus of claim 27, wherein said first smoother includes means for causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

29. The speech communication apparatus of claim 27, wherein said first division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said first ratio is produced.

30. A method of suppressing acoustic echo, comprising the steps of:

a) receiving a distant signal from a far-end talker and producing

acoustic energy of the distant signal from a signal output transducer;

b) producing a near-end signal from a signal input transducer which may contain a component representing a speech activity of a near-end talker or an acoustic echo component, or both, wherein said acoustic echo component occurs as a result of the distant signal being transmitted through an acoustic echo path from the signal output transducer to the signal input transducer;

c) producing an echo replica from said distant signal and a residual echo, detecting said residual echo between said near-end signal and said echo replica and using the residual echo as a feedback signal to produce said echo replica; and

d) receiving one of said near-end signal and said residual echo as a first input signal, receiving said echo replica as a second input signal, and estimating from the first and second input signals said acoustic echo component when said speech activity is low or zero; and

e) shaping spectrum of said first input signal with the estimated acoustic echo component.

31. The method of claim 30, wherein step (d) estimates said acoustic echo component for each of a plurality of subband frequencies of audio spectrum.

32. The method of claim 30, wherein step (d) estimates said acoustic echo component from a ratio of said first input signal to said second input signal.

33. The method of claim 30, wherein step (d) estimates said acoustic echo component from a ratio of said first input signal to said second input signal for each of a plurality of subband frequencies of audio spectrum.

34. The method of claim 30, wherein step (d) comprises:

d_1) dividing said first input signal into a first set of subband frequency component signals;

d_2) dividing said second input signal into a second set of subband frequency component signals;

d_3) receiving a corresponding one of the first set of subband frequency component signals as a first subband signal, receiving a corresponding one of the second set of subband frequency component signals as a second subband signal, producing an estimate of a subband acoustic echo component from the first and second subband signals, and shaping the first subband signal with the estimate of the subband acoustic echo component; and

d_4) combining output signals of said plurality of subband spectral shaping means.

35. The method of claim 34, wherein step (d_3) comprises:

producing a ratio of said first subband signal to said second subband signal;

smoothing said ratio when said speech activity is low or zero;

multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo component; and

producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

36. The method of claim 35, wherein the smoothing step causes said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

37. The method of claim 35, wherein the ratio producing step includes the step of smoothing said first and second subband signals before

said ratio is produced.

38. The method of claim 37, wherein the step of smoothing the first and second subband signals causes said first and second subband signals to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

39. The method of claim 34, wherein step (d) comprises:

d_1) producing a first ratio of said first subband signal to said second subband signal;

d_2) producing a second ratio of said second subband signal to said first subband signal;

d_3) smoothing said first ratio when said speech activity is low or zero;

d_4) multiplying the smoothed first ratio by said second ratio;

d_5) smoothing the multiplied smoothed first ratio;

d_6) subtracting integer 1 from the first ratio smoothed by step (d_5) to produce a subtracted signal; and

d_7) multiplying said first subband signal by said subtracted signal.

40. The method of claim 39, wherein step (d_3) includes the step of causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

41. The method of claim 39, wherein step (d_1) includes the steps of smoothing said first and second subband signals before said first ratio is produced.

42. The method of claim 30, further comprising accentuating harmonics components of said distant signal contained in said echo replica

before estimating said acoustic echo component.

43. The method of claim 30, wherein step (c) comprises the steps of:

dividing said residual echo into a first set of subband frequency component signals;

dividing said distant signal into a second set of subband frequency component signals;

adaptively filtering said second set of subband frequency component signals according to said first set of subband frequency component signals;

combining the adaptively filtered signals to produce said echo replica; and

nullifying the first set of subband frequency component signals when said speech activity is high,

wherein step (d) comprises:

receiving a corresponding one of the first set of subband frequency component signals as a first subband signal, receiving a corresponding one of the adaptively filtered signals as a second subband signal, and producing an estimate of a subband acoustic echo component from the first and second subband signals;

shaping the first subband signal with the estimate of the subband acoustic echo component; and

combining a plurality of said shaped first subband signals.

44. The method of claim 43, wherein the shaping step comprises:

producing a ratio of said first subband signal to said second subband signal;

smoothing said ratio when said speech activity is low or zero;

multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo component; and

producing a difference signal representative of the difference between

the first subband signal and said estimate of the subband acoustic echo component.

45. The method of claim 44, wherein the smoothing step causes said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

46. The method of claim 44, wherein the ratio producing step comprises the steps of smoothing said first and second subband signals before said ratio is produced.

47. The method of claim 46, wherein the steps of smoothing the first and second subband signals cause said first and second subband signals to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

48. The method of claim 43, wherein the shaping step comprises:

d_1) producing a first ratio of said first subband signal to said second subband signal;

d_2) producing a second ratio of said second subband signal to said first subband signal;

d_3) smoothing said first ratio when said speech activity is low or zero;

d_4) multiplying the smoothed first ratio by said second ratio;

d_5) smoothing the multiplied smoothed first ratio;

d_6) subtracting integer 1 from the first ratio smoothed by step (d_5) to produce a subtracted signal; and

d_7) multiplying said first subband signal by said subtracted signal.

49. The method of claim 48, wherein step (d_3) includes the step of

causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition..

50. The method of claim 48, wherein step (d_1) includes the steps of smoothing said first and second subband signals before said first ratio is produced.

51. A method of suppressing acoustic echo, comprising the steps of:

a) receiving a distant signal from a far-end talker and producing acoustic energy of the distant signal from a signal output transducer;

b) dividing said distant signal into a first set of subband frequency component signals;

c) producing a near-end signal by a signal input transducer, wherein the near-end signal may contain a component representing a speech activity of a near-end talker or an acoustic echo component, or both, wherein said acoustic echo component occurs as a result of the distant signal being transmitted through an acoustic echo path from the signal output transducer to the signal input transducer;

d) dividing said near-end signal into a second set of subband frequency component signals;

e) producing an echo replica from a corresponding one of said first set of subband frequency component signals and a subband residual echo, detecting the subband residual echo between a corresponding one of said second set of subband frequency component signals and said echo replica and using said subband residual echo as a feedback signal to produce said echo replica;

f) receiving said residual echo as a first subband input signal, receiving said echo replica as a second subband input signal, and estimating from the first and second input signals said acoustic echo component when said speech activity is low or zero;

g) shaping said first subband input signal with the estimated acoustic echo component to produce an output signal; and

h) combining a plurality of said output signals.

52. The method of claim 51, wherein step (g) comprises the steps of:

producing a ratio of said first subband signal to said second subband signal;

smoothing said ratio when said speech activity is low or zero;

multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband acoustic echo component; and

producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

53. The method of claim 52, wherein the smoothing step causes said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

54. The method of claim 52, wherein the ratio producing step includes the steps of smoothing said first and second subband signals before said ratio is produced.

55. The method of claim 54, wherein the steps of smoothing said first and second subband signals cause said first and second subband signals to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

56. The method of claim 51, wherein step (e) comprises the steps of:

e_1) producing a first ratio of said first subband signal to said second

subband signal;

e_2) producing a second ratio of said second subband signal to said first subband signal;

e_3) smoothing said first ratio when said speech activity is low or zero;

e_4) multiplying the smoothed first ratio by said second ratio;

e_5) smoothing the multiplied smoothed first ratio;

e_6) subtracting integer 1 from the first ratio smoothed by step (e_5) to produce a subtracted signal; and

e_7) multiplying said first subband signal by said subtracted signal.

57. The method of claim 56, wherein step (e_3) causes said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

58. The method of claim 56, wherein step (e_1) includes the steps of smoothing said first and second subband signals before said first ratio is produced.

59. A spectral shaper for cancellation of noise comprising:

means for dividing a first input signal into a first set of subband frequency component signals;

means for dividing a second input signal into a second set of subband frequency component signals;

a plurality of subband spectral shaping means, each of the subband spectral shaping means receiving a corresponding one of the first set of subband frequency component signals as a first subband signal, receiving a corresponding one of the second set of subband frequency component signals as a second subband signal, producing an estimate of a subband noise component from the first and second subband signals, and shaping the first

subband signal with the estimate of the subband noise component; and

means for combining output signals of said plurality of subband spectral shaping means.

60. The spectral shaper of claim 59, wherein each of said subband spectral shaping means comprises:

a division circuit for producing a ratio of said first subband signal to said second subband signal;

a smoother for smoothing said ratio when said first input signal is indicative of low or zero speech activity;

a multiplier for multiplying said second subband signal by said smoothed ratio to produce said estimate of the subband noise component; and

a subtractor for producing a difference signal representative of the difference between the first subband signal and said estimate supplied from said multiplier.

61. The spectral shaper of claim 60, wherein said smoother includes means for causing said ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

62. The spectral shaper of claim 60, wherein said division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said ratio is produced.

63. The spectral shaper of claim 62, wherein said first smoother includes means for causing said first subband signal to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition, and wherein said second smoother includes means for causing said second subband signal to vary sharply at a rising edge of a transition and vary

slowly at a falling edge of the transition.

64. The spectral shaper of claim 59, wherein each of said subband spectral shaping means comprises:

a first division circuit for producing a first ratio of said first subband signal to said second subband signal;

a second division circuit for producing a second ratio of said second subband signal to said first subband signal;

a first smoother for smoothing said first ratio when said first input signal is indicative of low or zero speech activity;

a first multiplier for multiplying the smoothed first ratio by said second ratio;

a second smoother for smoothing the output of said first multiplier;

a subtractor for subtracting integer 1 from the output of the second smoother; and

a second multiplier for multiplying said first subband signal by the output of the subtractor.

65. The spectral shaper of claim 64, wherein said first smoother includes means for causing said first ratio to vary sharply at a rising edge of a transition and vary slowly at a falling edge of the transition.

66. The spectral shaper of claim 64, wherein said first division circuit includes first and second smoothers for smoothing said first and second subband signals, respectively, before said first ratio is produced.